PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference AH:LF:FP21072	FOR FURTHER ACTION	See Form PCT/IPEA/416
International application No. PCT/AU2005/000296	International filing date *(day/month/year)* 2 March 2005	Priority date *(day/month/year)* 2 March 2004

International Patent Classification (IPC) or national classification and IPC

Int. Cl.

G02F 1/365 (2006.01)

Applicant

QUCOR PTY LTD et al

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 4 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. [X] *(sent to the applicant and to the International Bureau)* a total of 7 sheets, as follows:
      - [X] sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      - [ ] sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.

   b. [ ] *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or table related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).
4. This report contains indications relating to the following items:

[X]	Box No. I	Basis of the report
[ ]	Box No. II	Priority
[ ]	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
[ ]	Box No. IV	Lack of unity of invention
[X]	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
[ ]	Box No. VI	Certain documents cited
[ ]	Box No. VII	Certain defects in the international application
[X]	Box No. VIII	Certain observations on the international application

Date of submission of the demand 18 July 2005	Date of completion of this report 06 June 2006
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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/AU2005/000296

Box No. I **Basis of the report**

10/591417

1. With regard to the language, this report is based on:

[X] The international application in the language in which it was filed

[ ] A translation of the international application into , which is the language of a translation furnished for the purposes of:

[ ] international search (under Rules 12.3(a) and 23.1 (b))

[ ] publication of the international application (under Rule 12.4(a))

[ ] international preliminary examination (Rules 55.2(a) and/or 55.3(a))

2. With regard to the elements of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

[ ] the international application as originally filed/furnished

[X] the description:

pages 1-16 as originally filed/furnished
pages* received by this Authority on with the letter of
pages* received by this Authority on with the letter of

[X] the claims:

pages as originally filed/furnished
pages* as amended (together with any statement) under Article 19
pages* 17-23 received by this Authority on 16 February 2006 with the letter of 21 September 2005
pages* received by this Authority on with the letter of

[X] the drawings:

pages 1/4-4/4 as originally filed/furnished
pages* received by this Authority on with the letter of
pages* received by this Authority on with the letter of

[ ] a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing.

3. [ ] The amendments have resulted in the cancellation of:

[ ] the description, pages
[ ] the claims, Nos.
[ ] the drawings, sheets/figs
[ ] the sequence listing *(specify)*:
[ ] any table(s) related to the sequence listing *(specify)*:

4. [ ] This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

[ ] the description, pages
[ ] the claims, Nos.
[ ] the drawings, sheets/figs
[ ] the sequence listing *(specify)*:
[ ] any table(s) related to the sequence listing *(specify)*:

* *If item 4 applies, some or all of those sheets may be marked "superseded."*

Box No. V **Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims **1-44**	**YES**
	Claims	**NO**
Inventive step (IS)	Claims **1-44**	**YES**
	Claims	**NO**
Industrial applicability (IA)	Claims **1-44**	**YES**
	Claims	**NO**

2. Citations and explanations (Rule 70.7)

Novelty and Inventive Step

The Butler article discusses the application of CVD diamond materials with specific reference to the use of N-V defects in single photon quantum cryptography. See end of first paragraph in third column of page 22.

WO 2004/046427 discloses the deposition of diamond in waveguides, as crystals and in optic fibres for a wide range of optical applications.

US 2003/0021518 discloses an optical transformer comprising an optical fibre with a microsphere whereby light trapped within the microsphere causes transitions between modes of light as used in quantum algorithms.

None of the features of the claims are disclosed. Therefore the claims can be said to both novel and to have an inventive step.

Industrial Applicability

The claims are directly related to the manufacture of objects of semiconductor materials . Therefore the claimed invention can be said to industrially applicable.

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

Claims 28 and 40 are unclear as the steps involved in the making or growing of colour centres adjacent or in association with the waveguide. Where are the colour centers attached to the waveguide? How is it attached? Is the waveguide planar or a fibre? How much material is grown?

The Claims:

1. A photon source comprising:

an optical waveguide and

a material comprising at least one colour centre, the or each colour centre being arranged for emission of single or entangled photons and the material having been grown so that the material is bonded to the optical waveguide and in use at least some of the photons emitted by the or each colour centre are guided in the optical waveguide.

2. A photon source comprising:

an optical waveguide incorporating a material having at least one colour centre arranged for emission of single or entangled photons, the material being incorporated so that in use at least some of the photons emitted from the or each colour centre are guided in the optical waveguide.

3. The photon source as claimed in claim 1 or 2 being a source of single photons.

4. The photon source as claimed in claim 1 or 2 being arranged for emission of entangled photons.

5. The photon source as claimed in claim 4 comprising at least two colour centres which are arranged to emit together at least two entangled photons.

6. The photon source as claimed in claim 4 comprising at least one colour centre which itself is arranged to emit entangled photons.

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7. The photon source as claimed in any one of the preceding claims wherein the material has a diamond structure.

8. The photon source as claimed in any one of the preceding claims wherein the material is a diamond material.

9. The photon source as claimed in any one of the preceding claims wherein the material is grown on a portion of a core region of the waveguide.

10. The photon source as claimed in any one of the preceding claims wherein the material is a diamond crystal and the or each colour centre comprises a nitrogen-related colour centre.

11. The photon source as claimed in any one of claims 1 to 9 wherein the material is a diamond crystal and the or each colour centre comprises a nickel-related colour centre.

12. The photon source as claimed in any one of the preceding claims wherein the waveguide is an optical fibre.

13. The photon source as claimed in any one of claims 1 to 11 wherein the waveguide is a planar waveguide.

14. The photon source as claimed in claim 12 or 13 comprising a core region that is surrounded by a core-surrounding region which has a lower refractive index than the core region.

15. The photon source as claimed in claim 12 or 13 comprising a number of light-confining elements arranged about the core region so that light can be guided in the core region.

16. The photon source as claimed in claim 15 wherein the core region is solid and the light-confining elements result in an average refractive index of a core-surrounding region being lower than that of the core region.

17. The photon source as claimed in claim 15 wherein the light-confining elements are arranged so that a photonic crystal waveguide is formed having photonic bandgap in the core-surrounding region.

18. The photon source as claimed in any one of the proceeding claims wherein the material is positioned in a cavity which is located in the waveguide.

19. The photon source as claimed in claim 18 wherein the cavity is located in a core region of the waveguide.

20. The photon source as claimed in 18 or 19 wherein the cavity is an optical cavity.

21. The photon source as claimed in claim 2 or in any one of claims 3 to 20 when dependent on claim 2 wherein the material is embedded in the optical waveguide.

22. The photon source as claimed in claim 2 or in any one of claims 3 to 20 when dependent on claim 2 wherein the

material forms a part of the waveguide.

23. The photon source as claimed in claim 2 or in any one of claims 3 to 22 when dependent on claim 2 wherein the waveguide has a diamond core that comprises the or each colour centre.

24. The photon source as claimed in claim 2 or in any one of claims 3 to 23 when dependent on claim 2 wherein at least a portion of the length of the waveguide is composed of diamond.

25. The photon source as claimed in claim 24 wherein the entire waveguide is composed of diamond.

26. The photon source as claimed in any one of the preceding claims being arranged for optical excitation of the or each colour centre.

27. The photon source as claimed in any one of the preceding claims being arranged for electrical excitation of the or each colour centre.

28. A method of fabricating a photon source comprising:

providing an optical waveguide and

growing a material adjacent or in association with the optical waveguide in a manner so that at least one colour centre for emission of single or entangled photons is formed in the material.

29. The method as claimed in claim 28 wherein the material is grown in a manner such that the material is bonded to the optical waveguide and in use at least some

of the single photons emitted from the or each colour centre are guided in the optical waveguide.

30. The method as claimed in claim 28 or 29 wherein the material is grown directly on a portion of the waveguide so that a direct bonding of the optical waveguide with the material is effected.

31. The method as claimed in any one of claims 28 to 30 comprising the additional step of forming at least one recess in the optical waveguide.

32. The method as claimed in claim 31 wherein the waveguide comprises a core and a core surrounding region and the at least one recess is formed at an end-face of the waveguide in the core region.

33. The method as claimed in claim 31 or 32 wherein the recess is formed by etching the recess in the core region using an etch-process that preferentially etches material of the core region.

34. The method as claimed in any one of claims 28 to 33 wherein the material comprises diamond crystals having the or each colour centre.

35. The method as claimed in any one of claims 28 to 34 wherein the step of growing the material involves chemical vapour deposition (CVD).

36. The method as claimed in claim 31 or any one of claims 32 to 35 when dependent on claim 31 wherein the step of growing a material comprises growing the material

at an edge associated with the or each recess.

37. The method as claimed claim 31 or any one of claims 32 to 35 when dependent on claim 31 wherein the step of growing a material comprises growing the material in the or each recess.

38. The method as claimed in claim 37 wherein the material is grown at an end-face of the waveguide and the method comprises the step of splicing the end-face with an end-face of another waveguide.

39. The method as claimed in claim 37 wherein the material is grown at an end-face and in the or each recess and the method comprises the step of splicing the end-face with an end-face of another waveguide so that the or each recess is closed and forms a cavity comprising that material having the or each colour centre.

40. A method of fabricating a photon source comprising an optical waveguide, the method comprising the steps of:

fabricating an optical waveguide incorporating a material in which at least one colour centre for emission of single or entangled photons can be formed and

forming the or each colour centre in the material in a manner so that in use at least some of the emitted photons are guided in the optical waveguide.

41. The method as claimed in claim 40 wherein the optical waveguide has a core and the material forms a part of the core.

42. The method as claimed in claim 40 wherein the optical

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waveguide has a core which is composed of the material.

43. A photon source fabricated by the method as claimed in any one of claims 28 to 42.

44. A quantum key distribution system comprising the photon source as claimed in any one of claims 1 to 27.

CLAIMS AMENDED BY THE INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY DATED JUNE 6, 2006 (PCT/AU2005/000296)

1. A photon source comprising:

an optical waveguide and

a material comprising at least one colour centre, the or each colour centre being arranged for emission of single or entangled photons and the material having been grown so that the material is bonded to the optical waveguide and in use at least some of the photons emitted by the or each colour centre are guided in the optical waveguide.

2. A photon source comprising:

an optical waveguide incorporating a material having at least one colour centre arranged for emission of single or entangled photons, the material being incorporated so that in use at least some of the photons emitted from the or each colour centre are guided in the optical waveguide.

3. The photon source as claimed in claim 1 or 2 being a source of single photons.

4. The photon source as claimed in claim 1 or 2 being arranged for emission of entangled photons.

5. The photon source as claimed in claim 4 comprising at least two color centres which are arranged to emit together at least two entangled photons.

6. The photon source as claimed in claim 4 comprising at least one colour centre which itself is arranged to emit entangled photons.

7. The photon source as claimed in any one of the preceding claims wherein the material has a diamond structure.

8. The photon source as claimed in any one of the preceding claims wherein the material is a diamond material.

9. The photon source as claimed in any one of the preceding claims wherein the material is grown on a portion of a core region of the waveguide.

10. The photon source as claimed in any one of the preceding claims wherein the material is a diamond crystal and the or each colour centre comprises a nitrogen-related colour centre.

11. The photon source as claimed in any one of claims 1 to 9 wherein the material is a diamond crystal and the or each colour centre comprises a nickel-related colour centre.

12. The photon source as claimed in any one of the preceding claims wherein the waveguide is an optical fibre.

13. The photon source as claimed in any one of claims 1 to 11 wherein the waveguide is a planar waveguide.

14. The photon source as claimed in claim 12 or 13 comprising a core region that is surrounded by a core-surrounding region which has a lower refractive index than the core region.

15. The photon source as claimed in claim 12 or 13 comprising a number of light-confining elements arranged about the core region so that light can be guided in the core region.

16. The photon source as claimed in claim 15 wherein the core region is solid and the light-confining elements result in an average refractive index of a core-surrounding region being lower than that of the core region.

17. The photon source as claimed in claim 15 wherein the light-confining elements are arranged so that a photonic crystal waveguide is formed having photonic bandgap in the core-surrounding region.

18. The photon source as claimed in any one of the proceeding claims wherein the material is positioned in a cavity which is located in the waveguide.

19. The photon source as claimed in claim 18 wherein the cavity is located in a core region of the waveguide.

20. The photon source as claimed in 18 or 19 wherein the cavity is an optical cavity.

21. The photon source as claimed in claim 2 or in any one of claims 3 to 20 when dependent on claim 2 wherein the material is embedded in the optical waveguide.

22. The photon source as claimed in claim 2 or in any one of claims 3 to 20 when dependent on claim 2 wherein the material forms a part of the waveguide.

23. The photon source as claimed in claim 2 or in any one of claims 3 to 22 when dependent on claim 2 wherein the waveguide has a diamond core that comprises the or each colour centre.

24. The photon source as claimed in claim 2 or in any one of claims 3 to 23 when dependent on claim 2 wherein at least a

portion of the length of the waveguide is composed of diamond.

25. The photon source as claimed in claim 24 wherein the entire waveguide is composed of diamond.

26. The photon source as claimed in any one of the preceding claims being arranged for optical excitation of the or each colour centre.

27. The photon source as claimed in any one of the preceding claims being arranged for electrical excitation of the or each colour centre.

28. A method of fabricating a photon source comprising:

providing an optical waveguide and

growing a material adjacent or in association with the optical waveguide in a manner so that at least one colour centre for emission of single or entangled photons is formed in the material.

29. The method as claimed in claim 28 wherein the material is grown in a manner such that the material is bonded to the optical waveguide and in use at least some of the single photons emitted from the or each colour centre are guided in the optical waveguide.

30. The method as claimed in claim 28 or 29 wherein the material is grown directly on a portion of the waveguide so that a direct bonding of the optical waveguide with the material is effected.

31. The method as claimed in any one of claims 28 to 30 comprising the additional step of forming at least one recess in the optical waveguide.

32. The method as claimed in claim 31 wherein the waveguide comprises a core and a core surrounding region and the at least one recess is formed at an end-face of the waveguide in the core region.

33. The method as claimed in claim 31 or 32 wherein the recess is formed by etching the recess in the core region using an etch-process that preferentially etches material of the core region.

34. The method as claimed in any one of claims 28 to 33 wherein the material comprises diamond crystals having the or each colour centre.

35. The method as claimed in any one of claims 28 to 34 wherein the step of growing the material involves chemical vapour deposition (CVD).

36. The method as claimed in claim 31 or any one of claims 32 to 35 when dependent on claim 31 wherein the step of growing a material comprises growing the material at an edge associated with the or each recess.

37. The method as claimed claim 31 or any one of claims 32 to 35 when dependent on claim 31 wherein the step of growing a material comprises growing the material in the or each recess.

38. The method as claimed in claim 37 wherein the material is grown at an end-face of the waveguide and the method comprises the step of splicing the end-face with an end-face of another waveguide.

39. The method as claimed in claim 37 wherein the material

is grown at an end-face and in the or each recess and the method comprises the step of splicing the end-face with an end-face of another waveguide so that the or each recess is closed and forms a cavity comprising that material having the or each colour centre.

40. A method of fabricating a photon source comprising an optical waveguide, the method comprising the steps of:

fabricating an optical waveguide incorporating a material in which at least one colour centre for emission of single or entangled photons can be formed and

forming the or each colour centre in the material in a manner so that in use at least some of the emitted photons are guided in the optical waveguide.

41. The method as claimed in claim 40 wherein the optical waveguide has a core and the material forms a part of the core.

42. The method as claimed in claim 40 wherein the optical waveguide has a core which is composed of the material.

43. A photon source fabricated by the method as claimed in any one of claims 28 to 42.

44. A quantum key distribution system comprising the photon source as claimed in any one of claims 1 to 27.